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wisconsin engineer

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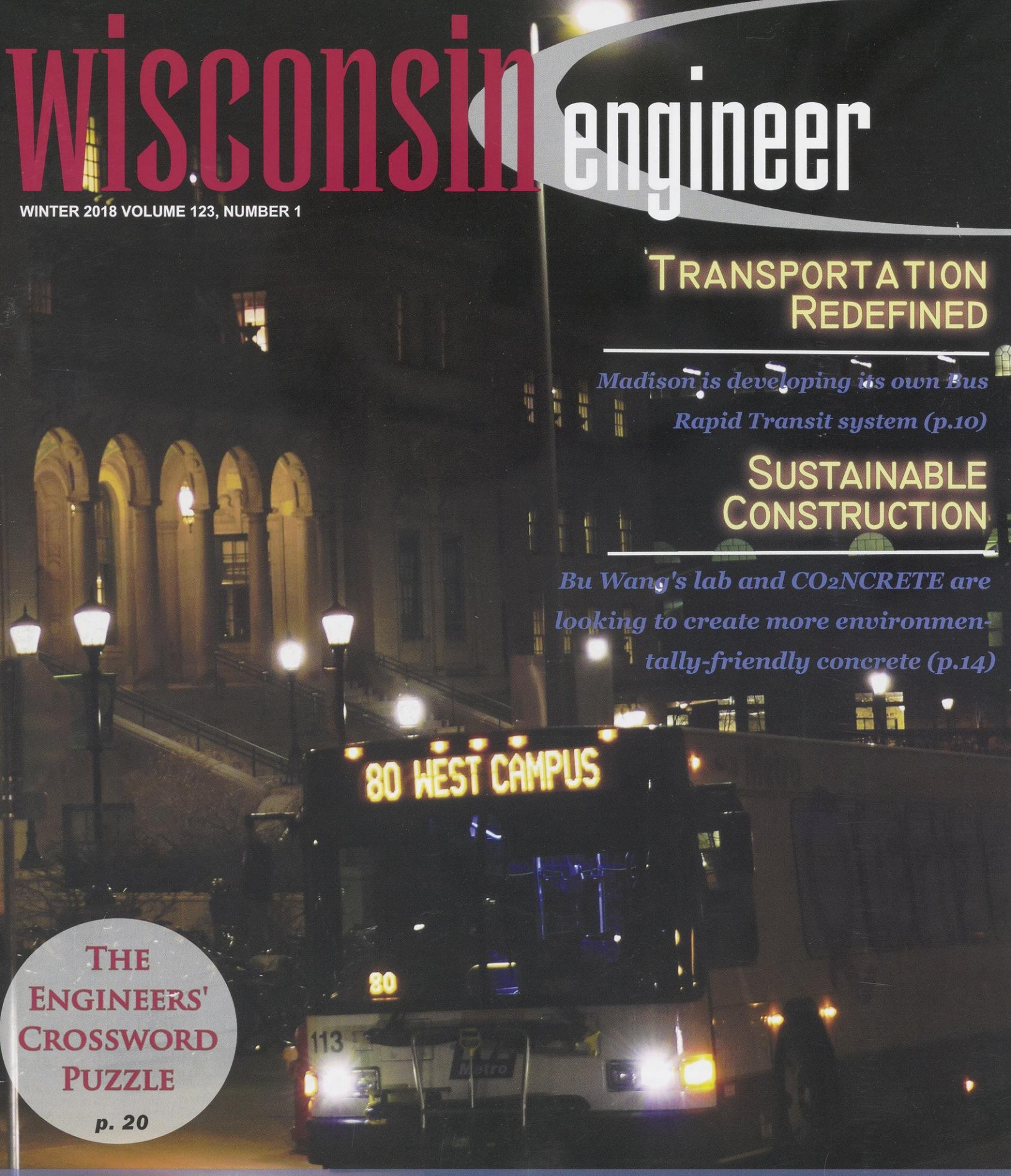

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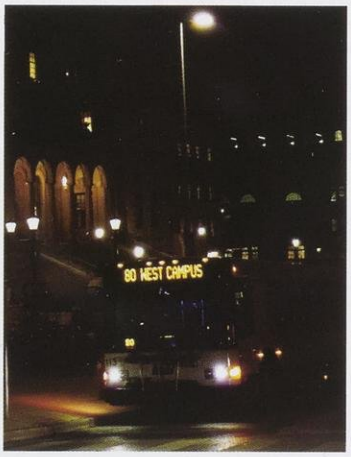
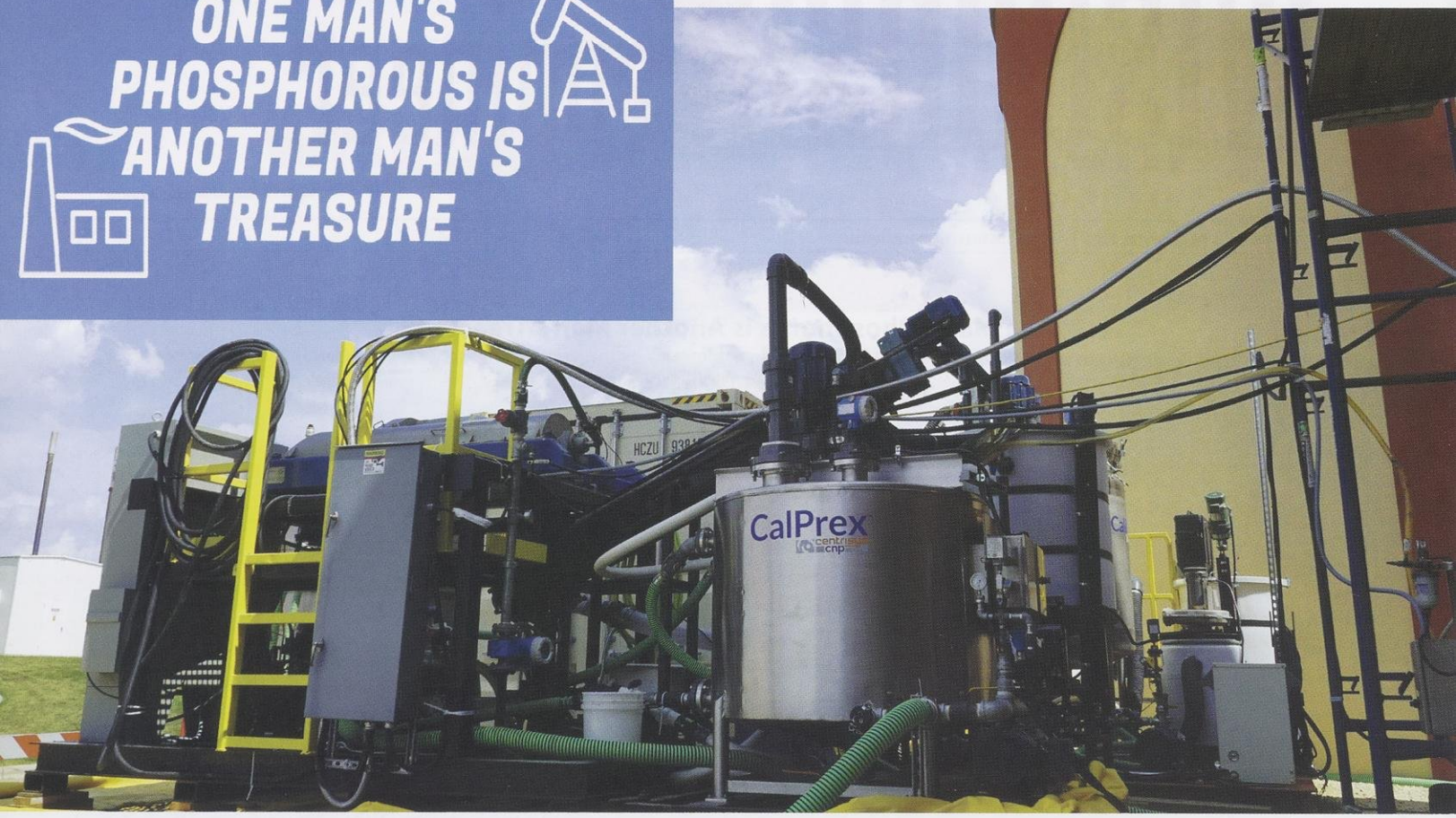
General



"Transportation Redefined"
Cover photo by
Jason Hakamaki

ONE MAN'S PHOSPHOROUS IS ANOTHER MAN'S TREASURE



In response to the world's unsustainable exploitation of phosphorus, Professor Barak has developed a process that recycles phosphorus from waste produced by sewage plants.

The saying "one man's trash is another man's treasure" is the motto of sustainable engineering. In a world of limited resources and an ever-growing population, finding ways to recycle nutrients from waste is essential for the survival of human civilization. A firm believer of this philosophy is Professor Phillip Barak from the UW-Madison department of soil science. Barak's research focuses on recovering phosphorus from wastewater to be used as fertilizer.

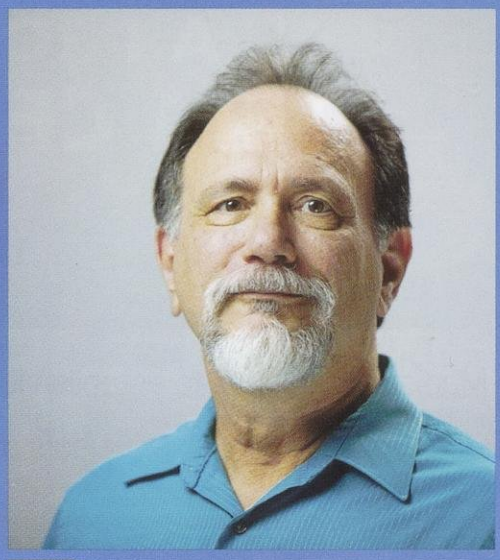
Phosphorus is an important nutrient in agriculture because it serves as fertilizer that grows, repairs, and maintains plant cells. The nutrient is found in natural deposits of phosphate rock and has been extracted since the 20th century to meet the demands of a growing population. However, current rates of phosphorus exploitation are not sustainable– the world has approximately 300 years' worth of phosphorus supply left. In fact, Barak anticipates humans will exhaust the amount in as little as 100 years as more countries begin to use phosphorus in their agriculture. He describes, "In 100 years, my grandchildren's children will be alive. Human civilization can't be allowed to collapse from agricultural shortages in 100 years."

To salvage the world's supply of phosphorus, Barak researches ways to extract phosphorus from places that accrue it as "trash." Then, he turns the phosphorus into "treasure" by converting the phosphorus into fertilizer. His work focuses on sewage plants because the waste these facilities produce when cleaning the water is rich in carbon, nitrogen, and phosphorus.

Typically, the sewage plant applies the nutrient-rich organic matter, called biosolids, to farmlands nearby so crops may recycle the phosphorus. However, over a prolonged period, this process is disadvantageous to both farmers and the sewage companies. Repeated cycles of this process cause the local farmland to exceed the threshold of phosphorus their plants can absorb. Consequently, the excess of phosphorus stays on the cropland and, with erosion, causes algae to grow in local waterways and damage the ecosystem. As a result, the sewage utilities must look to apply the biosolids at more distant locations, which can add thousands of dollars in transportation.

Professor Barak has observed that sewage systems are the perfect suppliers to meet the demand for phosphorus in the agricultural industry. He conducted years of research on phosphorus recovery with his two students, Dr. Mauricio Avila and Menachem Tabanpour. In 2011, the team developed their research into a company called Nutrient Recovery & Upcycling LLC (NRU) that extracts phosphorus from the biosolids produced by the sewage plants and converts it into usable fertilizer. "I realized that developing a company

Professor Barak's work focuses on turning phosphorous into fertilizer.



"This process takes what was originally a waste component of the treatment process and turns it into a usable and valuable product for large-scale agriculture."

- Professor Barak

would be the most effective way to ensure that the changes we propose are actually implemented," Barak says. NRU's technology attracted the interest of Centrisys Corp, a heavy equipment manufacturer in Kenosha, WI, and its CNP (Carbon, Nitrogen, Phosphorus) division, reaching a cross-licensing and minority ownership agreement for the company.

Specifically, Barak's process focuses on the plant's organic acid digester: the part of the purification process he describes as "pre-wash cycle for the anaerobic digestion of the sewage sludge." The acidic environment of the organic acid digester breaks down some of the solid forms of phosphorus and increases soluble phosphorus from 10-50 parts per million to 500-1000 parts per million. Then, a calcium hydroxide solution forms a compound called brushite with the phosphorus, which is then extracted from the mixture using a drying process involving a clarifier and a centrifuge. "This process takes what was originally a waste component of the treatment process and turns it into a usable and valuable product for large-scale agriculture," Barak says. Once the phosphorus is turned into a commercial form, it can be efficiently recycled to agriculture by sale to farms predicted (via soil tests) to show a crop response to the added phosphorus.

Currently, Barak's process is in the pilot-phase, occupying a 20 by 20-foot pad at the Nine Springs Sewage Treatment Plant in the Madison area under the auspices of the Water Research Federation and several water utilities from larger cities. The NRU pilot handles 5%-10% of the sludge from the plant's acid digester. Once the pilot results for phosphorus removal are published, they will be expanding to work with big utility companies in other major cities.

Professor Barak especially thanks the Madison Metropolitan Sewage District for being incredibly progressive in helping to develop his process by stating, "The Madison Metropolitan Sewage District has been very interested in the science of improving waste-water treatment ... Madison folks have been focused on getting things done."

The UW-Madison soil science department continues to be committed to sustainable engineering. Barak's current graduate students are conducting research in conjunction with NRU. In addition, Barak explains that the department is currently conducting research in wastewater treatment and recycling other forms of nutrient from sewage plants such as nitrogen. Engineering methods to turn "trash into treasure" is an important step toward sustainability. It is not only important for ensuring humans have enough phosphorus to meet agricultural demand but is also essential for the future of human civilization.

Written by: Sofia Noejovich
Photography provided by Professor Barak
Design by: Patricia Stan

A PROUD HISTORY of STEM CELL RESEARCH at UW Madison

UW–Madison continues to establish itself as a world leader in stem cell research through innovative projects and educational centers.

Cells, as the building blocks of life, have the power to conjure up feelings of hope as we ponder fundamental questions. Where are we from? What makes us human? How can we use the knowledge of cells to treat patients' diseases better? To answer these questions, we need to look into how cells work and what they are.

An exceptional learning environment always serves as an essential foundation for education. UW–Madison provides students with a wide variety of excellent resources and opportunities, as evidenced by its renowned reputation in several fields including stem cell research. An example of excellence in stem cell research comes from James Thomson, professor of regenerative biology at UW–Madison. Professor Thomson was the first in the world to derive human embryonic stem cells. According to Dr. Wan-Ju Li, associate professor in the department of orthopedics & rehabilitation and biomedical engineering, this is a pioneering work to demonstrate creation of human embryonic stem cells.

Embryonic stem cells are especially useful for medical applications. They are pluripotent, meaning that they can differentiate into all derivatives of the three primary germ layers: endoderm, ectoderm, and mesoderm, which arise early in an embryo and later develop into tissues and organs, and can produce an unlimited number of themselves. The discovery made by Professor Thomson, together with that of induced pluripotent stem cells discovered by Professor Shinya Yamanaka in Japan, allow biomedical engineers to dig deeper into human development and disease treatment.

UW–Madison has a proud history of stem cell research. In order to support the university's research in this field, a nonprofit organization named WiCell was created soon after Thomson first isolated human embryonic stem cells over 20 years ago to provide educational opportunities and technical support to UW stem cell research groups. The Stem Cell and Regenerative Medicine Center (SCRMC), launched in 2007, provides a platform for people interested in stem cells to

"People may not understand stem cells, but they will definitely one day benefit from stem cell research."
– Wan-Ju Li

where we were

James Thomson derived human embryonic stem cells for the first time.

WiCell, a nonprofit organization to support stem cell research is founded.

The Stem Cell and Regenerative Medicine Center is founded.

where we are now

Over 100 faculty members perform stem cell work at UW Madison

Stem cell research is divided into 5 groups:

- Blood Research Program
- Cardiovascular Regeneration Group
- Musculoskeletal Regeneration Group
- Neural Regeneration Group
- Stem Cell Bioengineering Group.

communicate, conduct various programs, and introduce philanthropic support for research in stem cells. As described by Professor Li, a member of the SCRMC, instead of being an institute with physical space, SCRMC works as an organization for all UW scientists interested in stem cell research. Over 100 faculty members perform stem cell-related work at UW–Madison from a variety of different departments. They are divided between five research focus groups: Blood Research Program, Cardiovascular Regeneration Group, Musculoskeletal Regeneration Group, Neural Regeneration Group, and Stem Cell Bioengineering Group. Professor Li is currently part of the musculoskeletal regeneration focus group and is the lab head of the Musculoskeletal Biology and Regenerative Medicine Laboratory. The mission of his lab is to find ways to control skeletal lineage differentiation of stem cells for developing therapies for patients with degeneration disorders.

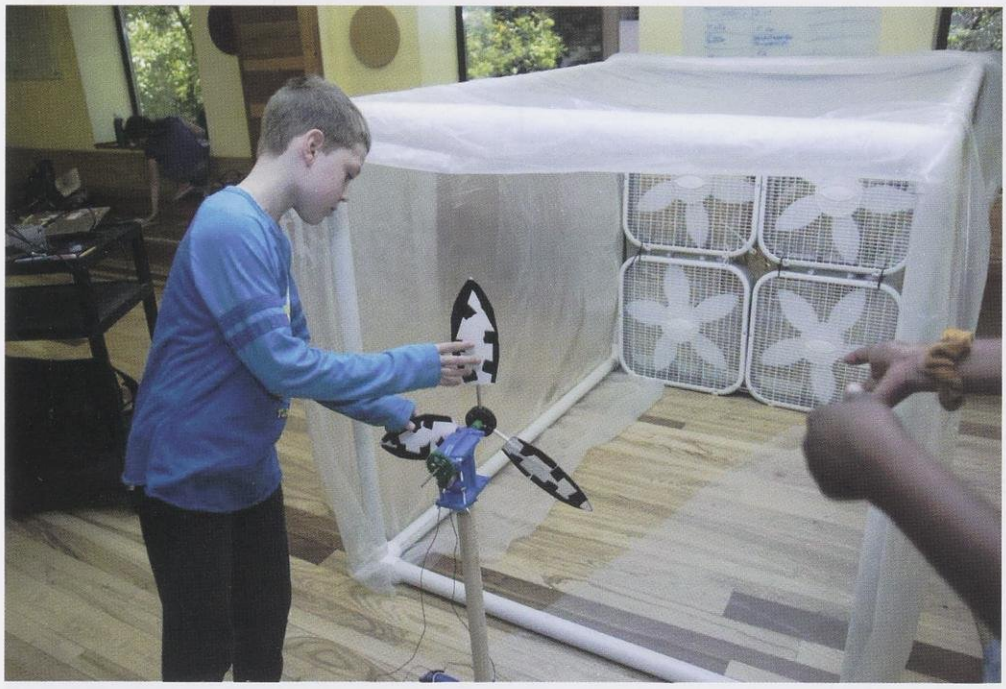
Professor Li highly encourages engineering students to learn more about stem cells. For biomedical engineering students, learning about stem cells is important since the cell can be used for disease treatment and tissue regeneration. Currently, Technology, and Entrepreneurship Changing Healthcare at the University of Wisconsin School of Medicine and Public Health (TECH-UWSMPH) is hosting an innovation challenge designed to provide students with relevant engineering experience with idea generation, product development, and entrepreneurship, especially within the medical field. TECH-UWSMPH requires engineering students to have a basic understanding of how medicine works so that they can work together with medical students to develop innovative projects.

Stem cells give us creative innovation and unique insights to this world and will continuously help medical and clinical development in the future. With such immense resources provided by UW–Madison, along with the importance of understanding stem cells, more college students are encouraged to learn more about cells so we can get closer to answering some of life's biggest questions.

Written by: Whitney Huang
Design by: Patricia Stan

Madtown Makers' Engineering Camp

UW–Madison professor Michael Arnold, along with student assistants, led a week-long summer engineering camp for elementary students.



A participant at the Madtown Makers' Engineering Camp works on a wind power design.

On June 25th to 29th of 2018, Dr. Michael Arnold, a professor from the department of materials science and engineering, along with graduate student Austin Way and undergraduate research assistant Jemimah Mawande, held a science and engineering camp for children in grades 3-5 at the Madison Children's Museum. The camp, named the Madtown Makers' Engineering Camp, focused on energy, engineering, and exploration. Students participated in activities such as a wind energy challenge, where they learned about and built models of efficient wind turbine blades. Energy is a topic close to Arnold's heart, as his research focuses on carbon-based nanomaterials and their advancements in energy and electronics. "The goal of this camp was to expose the kids to this topic, but also just to be fun and give them experience making and designing things," Arnold says. "New materials for energy applications is one of my research interests, and so this kind of meshes pretty well with the camp, which is looking at green energy."

The National Science Foundation Career Grant, which Arnold received about four years ago, made funding of the camp possible. The grant was created to help new assistant professors launch their research careers while conducting community outreach. This summer was the third time Arnold had run a children's camp. However, it was the first time he partnered with the Madison Children's Museum. Previously, Arnold had led camps for middle school students through the PEOPLE Program. "I think it's important to make an impact on kids at a really young age," says Arnold, "that's a foundational time where they don't really realize it, but they are making decisions about what they like and what they don't like in terms of careers or disciplines."

Transitioning from a middle school curriculum to an elementary one was one of Mawande's biggest tasks. She controlled most of the logistics for the camp as well, such as scheduling camp activities and budgeting. Although she enjoyed designing the curriculum, it was initially challenging. "I did not know the levels of comprehension of certain things," says Mawande. "[There] was a challenge with gauging what would be challenging enough but not too challenging or too boring." Nonetheless, Mawande found this experience valuable. Her favorite part was watching the children make friendships with each other and the camp teachers. "At the beginning they were super timid and kind of awkward," says Mawande, "then you give kids an hour in one room together and they are suddenly connecting to each other and to us." Daily, the students learned about a specific topic, followed by a related engineering challenge. They also partook in team building and other exploratory activities such as making solar s'mores. "They also actually learned and retained the information," Mawande says, "I do not know if they actually did after that week, but that was really cool to see."

"I think it's important to make an impact on kids at a really young age. That's a foundational time where they don't really realize it, but they are making decisions about what they like and what they don't like in terms of careers or disciplines."
– Dr. Michael Arnold

Wisconsin Children's Museum Director of Education, Kia Karlen, oversaw the camp specifics. She coordinates different educational summer programs for the museum. She ensures that each camp has all necessary materials, each itinerary is set, and that each camp is ready to run by the summer. "I tried to help Austin and Jemimah plan on how to scale the age from middle school to elementary school and help them develop a sense of whether there was enough for a camp

A student participating in the Madtown Makers' Engineering Camp works on one of the many engineering projects the camp ran.

session," Karlen says, "Part of the camp goals are simply around kids meeting new kids and learning to socialize with kids who are not from their school or who are different grade levels."

For UW–Madison students who want to get involved in outreach through the Madison Children's Museum, there is a summer internship position available through the museum, as well as other collaborations with different organizations. Madtown Makers' Engineering Camp is one of many ways that engineering faculty and students can give back to the community. Such experiences are valuable as they instill a passion for STEM fields in children at a young age. Additionally, they are excellent opportunities to develop character and leadership skills for engineering students. In just a week of camp, one can inspire the future's brightest engineers.

Written by: Isabella Wegner

Photography courtesy of Madison Children's Museum

Design by: Isabella Wegner

UW-Madison student, Jemimah Mawande, works with a camper on the wind turbine challenge at the Madtown Makers' Engineering camp, hosted at the Madison Childrens' Museum.

Encouraging Diversity in STEM Fields

Inclusion and diversity are necessary not only for success of underrepresented groups but for our commuity as a whole.

The advancement of science, technology, engineering, and mathematics (STEM) fields is paramount for the development of our national society, as innovations resulting from them have an immediate impact on nearly every aspect of American citizens' lives. Knowing this importance, many education and research institutions must ensure the diversity that is representative of this country is represented in our STEM education systems. Why is this necessary? Diversity has the special ability to unite and include all people, no matter their background or experiences. Embracing the ability of all experts, regardless of their race, religion, gender, or sexual orientation, will provide many valuable insights and perspectives into figuring out solutions to previously unsolvable problems. However, its realization proves to be challenging even when America is considered to be the "melting pot" of almost every culture in the world.

Diversity is a double-edged sword. While it has the potential to be one of the greatest assets that this country can offer, it can also be a huge obstacle for future development. It has become a public stigma that diversity often breeds conflict as a result of the overwhelming differences between people. Consequently, it has always been a controversial topic of debate. Despite this hardship, many people of diverse backgrounds continue to come to the United States with plans to pursue their passions and dreams. The diversity that already developed within the country puts the United States in a unique position. This country has become a beacon of diversity and opportunity, which attracts more talent from around the globe. This, in turn, raises various questions regarding the state of diversity in the United States. How should educational institutions best accommodate and encourage diversity? What is the impact of the incoming wave of international students and faculty for the STEM field? What is the most important component for this initiative to succeed? The magazine explored these questions with Dr. Robert Mathieu, director of the Wisconsin Center for Education Research.

"Mutual respect is the key to encouraging diversity" – Robert Mathieu

According to Dr. Mathieu, diversity is something that people, especially those who work in STEM fields, need to embrace and support for success. He firmly believes that in order to encourage more diverse people to enter STEM fields, educational institutions first have to adjust their learning environments so that "underrepresented groups (URGs) feel welcomed." According to Mathieu, various methods can be implemented to achieve this goal, such as incorporating broader cultural examples into course materials and forming small learning groups so more students, including students from URGs, have more opportunities to participate. Mathieu also argues that the diversification of faculty is critical for the success of all students. "Mutual respect is the key to encouraging diversity," Mathieu says. This diversification is important because it allows educational institutions to create a more welcoming environment for URG students.

In addition to the domestic URGs, Mathieu also emphasizes the significance of the presence of international URGs. He explains, "Including international perspectives is fundamental to the success of the nation." However, as Mathieu points out, the challenges of international URGs can be different from domestic URGs.

From Dr. Mathieu's interview, it is clear that even though diversity is a crucial component for the future success in STEM fields, encouraging it can be quite challenging as diversity may create the potential for conflicts. However, it can be achieved through several approaches, including the adjustment of the learning environment to be more inclusive and course materials to be more culturally relatable so that not only domestic URGs can relate, but also international URGs. All of these efforts have to be complemented with the presence of mutual respect between individuals. Hopefully, with all these methods, more people with diverse backgrounds will want to join the family of STEM experts and contribute to not only the development of the United States, but also the entire human civilization.

Written by: Alfred Sunaryo

Design by: Julia Mauser

The Magic of a Computer

Learn how Dr. Li's curiosity in an old Toshiba computer as a young girl led to an accomplished and fulfilling career in computer and electrical engineering.

Today, it's difficult to imagine a life without technology. In fact, it is common for children to grow up with both an iPad and a laptop. However, this wasn't always the case. Indeed, for Dr. Jing Li, assistant professor in the department of electrical and computer engineering, the old Toshiba computer her parents gave her as a teenager opened up a whole new world. "I was very, very curious," she explains, "about how when you write a piece of code, you can magically teach a machine to do the same thing as a human." With this entirely strange and untraversed source of potential available at her fingertips, Dr. Li took it upon herself to not only understand what was going on inside of this sophisticated "box"— its processes, its building blocks, its "intelligence"— but to also, one day, improve it. From there on, her mission was to hack the secrets of the computer and her dream to make a difference within the field.

Dr. Jing Li, assistant professor in the department of electrical and computer engineering.

Growing up in the city of Xuchang, China during the 1990s, Dr. Li was forced to live without a lot of luxuries that many take for granted. It was a time and a place that both lacked the resources for a comprehensive computer science curriculum (including the Internet) and heavily discouraged women from pursuing STEM majors. Nonetheless, when told that young girls were best suited for a career in art or music, and that she stood no chance against the boys, she never listened. "Most of the time," she recalls, "I would just try to play with [my computer] piece by piece, understanding the different tools in the operating system on my own, and even changing some of the riskier things that people told me not to change. It's very hard for a single person to understand every aspect of computers," Li says.

Dr. Li has conducted research in a variety of areas, including architecture-aware algorithm design, associative/cognitive computing, reconfigurable computing and design automation, among many others. One can't help but notice how Dr. Li is currently living out her early childhood aspirations. Much of her work today spans a large portion of the computer and electrical engineering spectrum, bridging the gaps between hardware and software, and also seeks progressive departures from the status quo. Thus, not only has Dr. Li become proficient in her sheer knowledge of computers, but she is also fulfilling her mission to improve them through exploring "non-conventional computing paradigms" that will make computers "faster, more compact, more intelligent, energy efficient, and easy to use."

Today, Dr. Li can boast a handful of amazing achievements such as the NSF Career Award, the Dugald C. Jackson Faculty Scholar of Electrical and Computer Engineering, and the A-Level IBM Outstanding Research Division Technical Achievement Award for Storage Class Memory. Looking back, Dr. Li's obstacles only render her achievements more impressive.

When one is facing similar challenges, seeing past them may be difficult. Without the proper circumstances or encouragement, one might undervalue oneself and shy away from something rather daunting, such as a woman pursuing a major in computer science. Dr. Li shared her words of wisdom regarding the subject. Examining the demographics of her own classroom, Dr. Li notes a lack of female enrollment and states that "there is definitely some effort that we have to make." Her own part in this solution is being a role-model for girls in the field and share her journey with them. Dr. Li explains that she hears a lot of girls worry that electrical and computer engineering is too hard, especially for girls, and so she will always tell them (with a heartwarming degree of modesty), "Don't be scared! Look, I can do it! And I'm not even that smart!" Of course, while many would disagree with the latter half of that statement, this type of encouragement can be transformative. Now well-established in her career, Dr. Li says that she still holds on to the early memories and people that initiated her down her path. "I still remember everybody's name" says Dr. Li. She also recalls how fondly she held onto that original Toshiba computer throughout her entire college education¬. "It was just such a precious gift to me," Li says.

And perhaps therein lies the answer to getting more people involved in STEM. The most valuable resource in the world is people's innate fascination with how things work—they want to know the explanation behind the magic. Access to proper resources and guidance is important. However, it matters less if a student is equipped with an urgent sense of curiosity—an experience or a question that makes them thirsty for knowledge. In fact, Dr. Li believes that it was her lack of resources when she was a child that truly fueled her interests, as it made her become desperate to want to learn more about how that computer worked. Thus, putting science in the hands of students and providing opportunities to peak their interest (such as science fairs, demonstrations, field trips) is imperative to broaden STEM participation. In the words of Dr. Li, when it comes to science and technology, "Just get your feet in the door. Experience it. Who knows, you may even like it."

Written by: Brianna Tobin
Photography by: Mayukh Misra
Design by: Amy Lossen

Madison's New Bus Rapid Transit System

Like many modern cities, Madison will soon have its own rapid transit system. But unlike other cities, its new system will not involve a railway– instead, it will be an efficiently designed, high-speed bus system.

When people hear the words "rapid transit," they tend to think about rail transportation in big cities, like the subway system of New York City or the "L" in Chicago. Rapid transit rail is a fast and highly efficient form of public transportation, but the cost to implement it can be steep. That's why smaller U.S. cities, including Madison, have turned to rapid transit rail's cost-effective counterpart, Bus Rapid Transit (BRT). Within as little as five years, Madison will have its own BRT system. But what distinguishes Bus Rapid Transit from an ordinary bus system? What must be done before the new system opens? And what effect will this new form of transportation have on UW-Madison students? Will Schaefer, the Transportation Planning Manager of the Madison Area Transportation Planning Board was able to shed some light on these questions.

According to Schaefer, "The area has been studying the idea for rapid transit service ... for decades, going back to the 1980s." It was only in 2013, however, that the Transportation Planning Board seriously began to consider BRT as opposed to rail or light rail options. Because Bus Rapid Transit systems require far less infrastructure to be built compared to rail transit systems, BRT is a more prudent solution for a city with a smaller population size, like Madison, where adequate funding is a practical limitation.

The planned Bus Rapid Transit system will allow commuters to shave several minutes off their commute time. The BRT will arrive at each bus stop every 10 minutes during peak travel time and every 15 minutes during the rest of the of day, which is a major improvement upon the current bus system that only comes every 30 minutes for most routes. To achieve this level of efficiency, the BRT system will have fewer stops and its own separate bus lane on the streets. Commuters will pay for their fare at new, invitingly designed stations before getting onto the bus, which will speed up the bus-loading process. Additionally, the BRT will use articulated buses, buses segmented in the middle by an accordion-like structure, which will hold about 20-30 more seated passengers than the current city buses. The articulated bus doors will also be level with loading platforms, cutting down on delays when the bus driver previously had to pull out a ramp for wheelchair-users or people with baby strollers. Bicyclists can also roll their bikes straight onto the bus and store them in the accordion portion of the articulated bus, instead of affixing their bikes to the front of the bus. These new buses will also be environmentally friendly, as they will be hybrid or completely electric vehicles.

Although all these changes will help shorten

Within as little as five years, Madison will have its own BRT system. But what distinguishes Bus Rapid Transit from an ordinary bus system? What must be done before the new system opens? And what effect will this new form of transportation have on UW-Madison students?

The BRT system aims to simplify bus travel by eliminating overlapping routes and multiple bus transfers. Pictured left: West Transfer Point. Pictured right: Wisconsin School of Business.

travel time, any new transit system requires approval and funding. The 2013 Transit Corridor Study has shown that this project is compatible with the existing infrastructure and will be beneficial to the Madison area. The Madison Bus Rapid Transit has also been approved by the City of Madison. However, funding still must be secured (possibly from grants from the Federal Transit Administration) to conduct a new study investigating how the first segment of the BRT, the "East-West Corridor" running from East Towne Mall to West Towne Mall, should best be implemented. There are also plans for the creation of lines in the north and south areas of Madison, running along Sherman Avenue and Park Street, respectively. If all funding and approval continues smoothly, the East-West Corridor should be opened "hopefully within five years," says Schaefer.

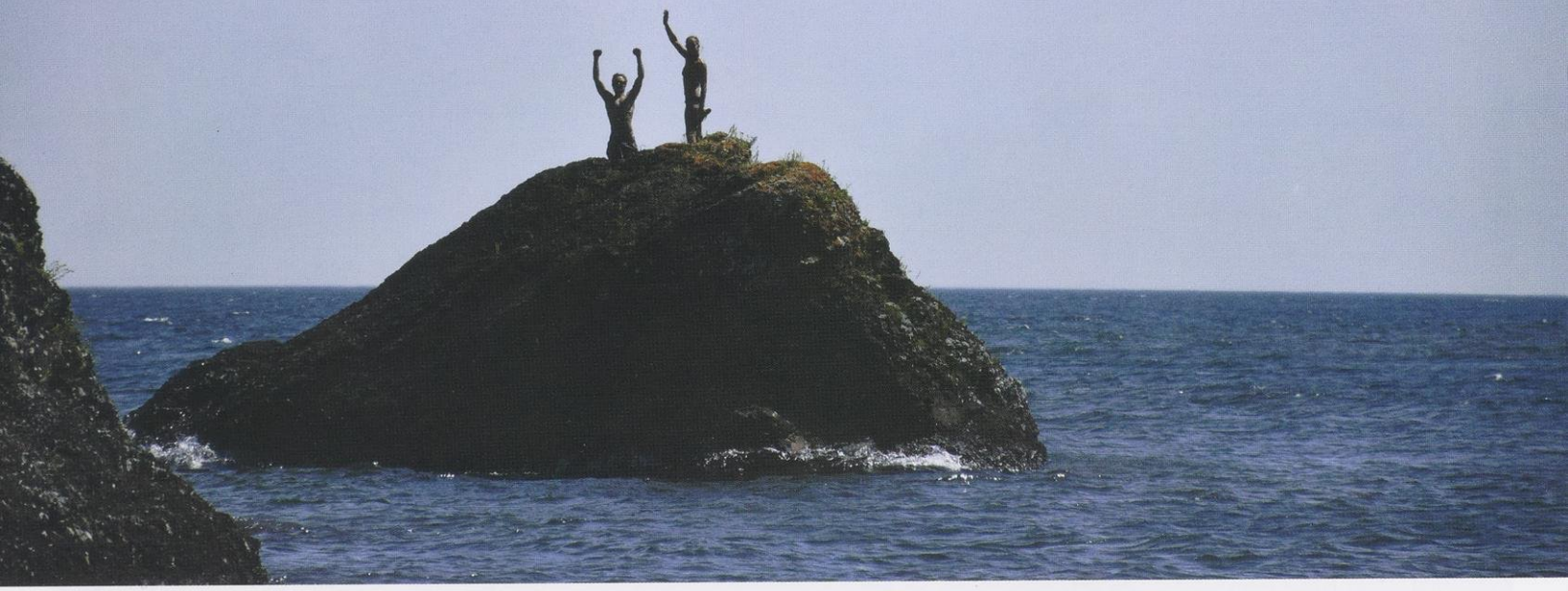
The new BRT system should have a positive effect for UW-Madison students and Madison residents. "[The new BRT system] will provide a more time-competitive transit trip for people … living further out from campus and people needing to travel across town" says Schaefer. The speed of the BRT system makes it competitive with other current forms of transportation, such as cars, mopeds, and bikes. The East-West corridor will be alongside University Avenue, allowing students to travel further from and to campus in a timely manner. The singular route will simplify bus travel by eliminating overlapping routes and the need for multiple bus transfers. BRT bus fare should also be comparable to the current bus system, making it accessible for the entire community. For students who will not be living along the East-West corridor, a modified version of existing bus system will still cover their transportation needs. In the future, they may benefit from the additional routes along Sherman Avenue and Park Street.

Schaefer is hopeful for the future of the BRT and its impact on the Madison area. In the future, the BRT may extend to other nearby communities, such as Fitchburg, Sun Prairie, and Verona. This will allow some UW-Madison students to visit home more often and would give others a chance to explore outside of the city. The new BRT system will foster a greater sense of community between Madison and neighboring towns. But for now, UW-Madison students and Madison residents alike have a lot to look forward to in their future travel plans.

Written by: Erica Calvache
Photography by: Jordan Bovee
Design by: Suzanne Kukec

Thunderstorms. . . With a Chance of Tsunami?

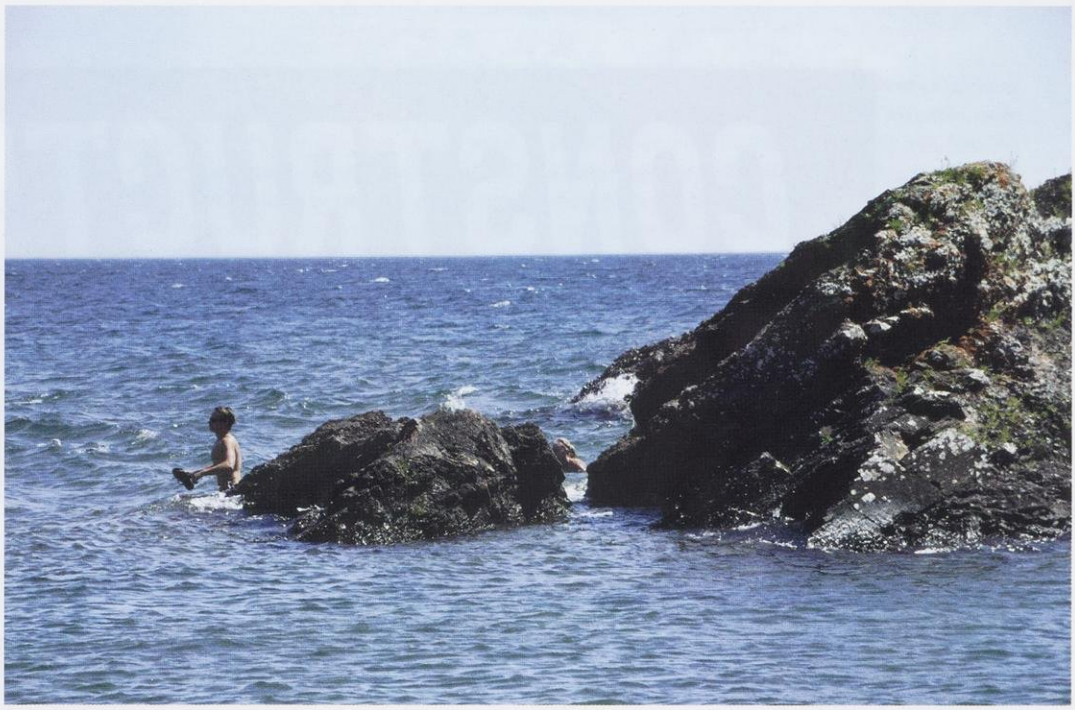
It turns out that you don't have to travel far to see a tsunami, after all. Dr. Chin Wu explains the dangers of meteotsunamis in the Great Lakes.



If you grew up in Wisconsin, there was an established vocabulary for natural disasters: tornadoes, blizzards, and thunderstorms. The only times one heard words like 'hurricane' or 'earthquake' were during the newscast. Dr. Chin Wu, a professor of civil and environmental engineering at UW–Madison, is working on introducing "tsunami" into this vernacular with the specific term "meteotsunami," or meteorological tsunami. Although he is considered one of the leading researchers on the topic, Dr. Wu didn't initially target meteotsunamis with his research. His involvement in the topic came unexpectedly. "Ten years ago, I had a PhD student working in Sheboygan. We noticed that every time a storm came in, the water levels went crazy. After looking at some historical articles, we began to understand what we were seeing," Wu says. Beside his meteotsunami research, Dr. Wu is working on a variety of coastal hazards like flooding, rip currents, freak waves, extreme storms, and coastal bluff erosion. He hopes his research will help mitigate these hazards and foster the resilience of the coastal communities in the Great Lakes.

While a traditional tsunami occurs due to an earthquake or other seismic upheaval, a meteotsunami is strictly weather-related. A meteotsunami is created when a storm front passes over a body of water. The storm front can create disturbances of water with strong winds or a rapid increase in atmospheric pressure. The displaced water creates a surge that reveals itself as a large wave upon approaching land. This phenomenon is not restricted to large bodies of water and has been occurring anywhere from the ocean to your local lake.

Each year we have roughly 100 meteotsunamis in the Great Lakes, according to Dr. Wu. April through July are the peak months of meteotsunami occurrence in the Great Lakes due to the abundance of storm fronts during these months. They can generate waves from two to ten feet high, and approximately one to five cause recordable damage every year. This phenomenon has a history of damage and fatalities due to its unexpected nature. For instance, on July 26, 1954 a large wave, attributed to a meteorological tsunami, swept fishermen off a pier in Chicago, killing seven. On May 27, 2012, three swimmers were rescued after a meteotsunami swept them a half-mile into Lake Erie



Waves crashing into rock outcrops on the shoreline of Lake Superior in Copper Harbor during calm weather conditions.

near Madison, Ohio. The occurrence and magnitude of meteotsunamis will only be intensified with climate change, and this could lead to severe coastal disasters, Dr. Wu warns.

The speed of a storm needed to produce a meteotsunami can be estimated by the depth of the body of water. The shallower the body of water, the lower the velocity required for meteotsunami formation. Take Lake Michigan and the Lake Superior, for example. Lake Michigan's average depth is 279 feet, while Lake Superior's is 483 feet. It follows that there have been 12 historically significant events related to a meteotsunami on Lake Michigan, yet only three on the much deeper Lake Superior.

Lake Michigan's shoreline happens to be home to many highly populous areas, such as Milwaukee and Chicago. These large cities have nuclear power plants and older buildings that are at risk of damage from meteotsunamis. Nuclear power plants are the largest concern, as they use water from Lake Michigan to cool their reactors. As Dr. Wu explains, "On the backside of a meteotsunami, with receding water levels, you might not have enough water to cool the nuclear power plant. This could last two minutes to two hours and could cause immense damage to the reactor." Clearly, meteotsunamis have a large potential for significant material loss and danger to life, just as with more traditional tsunamis. The concerning difference between the two? Regular tsunamis have established warning systems worldwide, while the Great Lakes have no such system in place.

"A significant challenge with meteotsunamis is that they come in about four to five hours in the Great Lakes. Regular tsunamis can have a warning of up to about 24 hours."
- Dr. Chin Wu

In 2017, Dr. Chin Wu led the first U.S. meteotsunami summit, which took the first steps towards creating a meteotsunami warning system. "By monitoring wind speed and storms and relating that to the geometry of the lakes, a warning can be sent out. A significant challenge with meteotsunamis is that they come in about four to five hours in the Great Lakes. Regular tsunamis can have a warning of up to about 24 hours," explains Dr. Wu. This short time frame makes the designing of a warning system particularly challenging. Working with NOAA Great Lakes Environmental Research Laboratory and National Tsunami Hazard Mitigation Program, Dr. Wu hopes to have a warning system set in place by 2023. This system will undoubtedly prevent property damage and save lives.

Even outside of his profession, Dr. Wu doesn't shy away from the water. He loves traveling around the Great Lakes in his free time and is an avid Badger football fan, with his favorite game day activity being, not surprisingly, the wave.

Written by: Johnathon Brehm
Photography by: Jordan Bovee
Design by: Amy Lossen

CONSTRUCTING MORE SUSTAINABLE CONCRETE

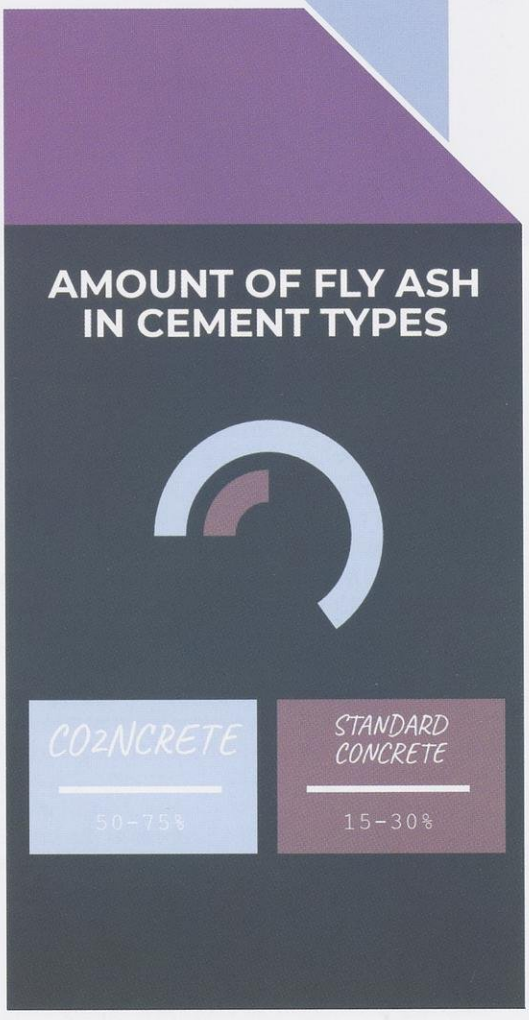
Concrete is the most produced material in the world – it is also one of the most damaging for the environment. Bu Wang and researchers at CO_2NCRETE are looking to change that.

Concrete is the single most widely produced and used material in the world, and it upholds a substantial carbon footprint. Producing large quantities of concrete is the leading cause for this detrimental impact on the environment. Concrete is used in excess for vast applications and purposes, contributing five percent of global carbon dioxide annually. In fact, for every ton of concrete produced, approximately one ton of carbon dioxide is also produced1. The material that bonds the concrete mixture together, Portland cement, is responsible for the environmental and economic concerns of concrete. Traditional concrete is composed of fine and coarse aggregate bonded together with Portland cement mixed with water. When the Portland cement is mixed with water, it undergoes a hydration process that results in a hard, strong material quickly. Not only are tremendous amounts of energy required to reach reaction temperatures required for this process, but the reaction of cement is the breakdown of calcium carbonate into calcium oxide and carbon dioxide1. This means that the large-scale production of cement yields a significant contribution to the world's carbon footprint.

One way to alleviate the detrimental environmental effects of concrete is to replace a portion of the Portland cement with fly ash. Fly ash is a material that results from the burning of coal, which creates a significant burden to coal burning power plants due to the waste control mandated practices. Although around 60% of produced fly ash is used for practical purposes, the rest is typically dumped into a pond near the coal burning facility or is landfilled.

Approximately 50 million tons of fly ash are deposited into the environment each year in the United States. The use of fly ash in cement is a novel and viable option to mitigate some carbon dioxide production in cement by replacing a portion of Portland cement; however, fly ash can currently only be a small portion of the cement composition. The fly ash material does not react with water in the same way as the Portland cement, resulting in a slower reaction. For this reason, fly ash can typically only compose 15 to 30 percent of the cement.

A team of scholars at University of California, Los Angeles (UCLA) have been researching a new curing process, carbonation, which is a reaction between carbon dioxide and a calcium containing compound. Dr. Bu Wang, a new assistant professor in the department of civil and environmental engineering at UW–Madison, is on this team of researchers. Wang says that by using carbonation, the cement can be composed of 50 to 75% fly ash, containing very little Portland cement. The researchers coined the new material CO_2NCRETE and entered this material in a competition called Carbon XPRIZE. Carbon XPRIZE is a 20 million dollar carbon dioxide utilization technology competition. The CO_2N



"Portland cement has been the same for over a century now. Having done this for so long doesn't mean this is the best way to do it."
- Dr. Bu Wang

CRETE research group is now in the final round of the competition.

The benefits of using fly ash in concrete are two-fold. First, fly ash is a waste material produced in large quantities, usually dumped in a pond or landfill. Some ashes can be toxic and pose public health risks if released into the environment due to a hurricane or other natural disaster. This year, hurricane Florence released tons of ash in North Carolina. Second, the coal burning power plants must pay for the handling of fly ash as a waste material. Now the fly ash that can be used for concrete construction can sell for 80 dollars per ton. Thus, both power plant and ratepayers can benefit economically from coal ash utilization. Replacing Portland cement with fly ash is also attractive for concrete production, an industry with relatively low profit margins, because the fly ash is cheaper than the Portland cement. Proper use of fly ash in concrete can also improve its workability, long-term strength, and durability. Road pavement would last longer, road conditions would be improved, and road construction would cost less all because of utilization of fly ash in cement.

Concrete has been used for a long time as a construction material. "Portland cement has been the same for over a century now. Having done this for so long doesn't mean this is the best way to do it," Wang says. The harsh environmental impact of concrete may be relieved in the future as concrete technology is improved and new materials emerge. In the meantime, one major obstacle to be faced with the transition to fly ash cement is the limiting fly ash content of cement mandated by ASTM standards. Currently, only 20 to 30 percent of cement can be fly ash, leaving a large portion of fly ash unused. Another major obstacle is the type of fly ash that can be used to replace the Portland cement. Because specifications required fly ash to meet certain classifications, concrete construction is only able to use less than 40% of the fly ash produced each year.

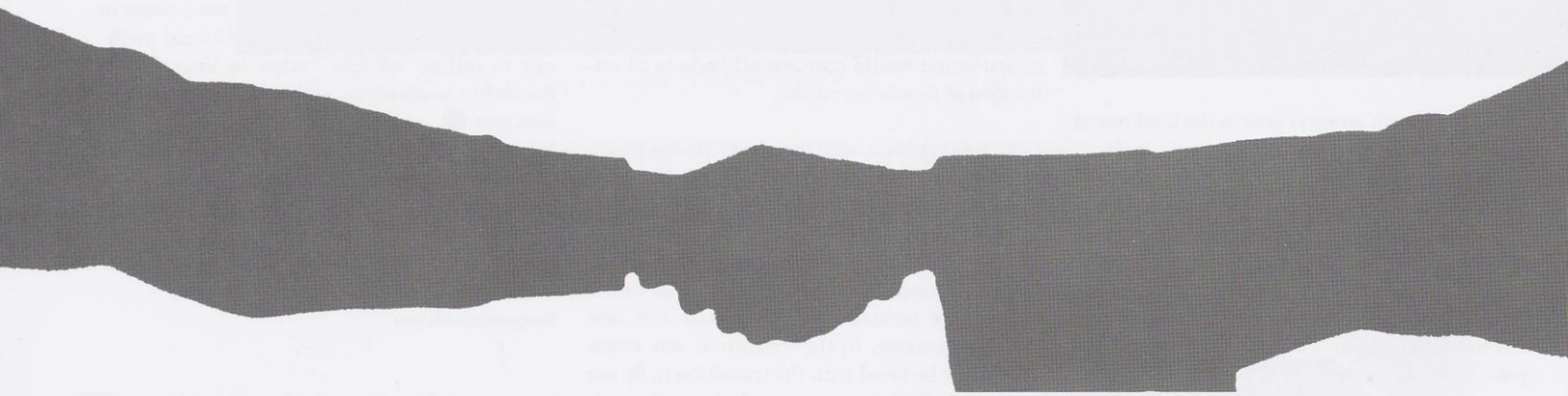
Continuing in his research, Wang looks forward to trying new cement and concrete compositions to not only further increase the fly ash content in cement, but also develop non-traditional methods to utilize "off-spec" ashes to improve the durability, economics, and carbon footprint of concrete.

1. chemistryworld.org. (2008). The Concrete Conundrum. [online] Available at: http://www.rsc.org/images/Construction_tcm18-114530.pdf.

Written by: Sarah Gerarden
Design by: Patricia Stan

Welcome to Handshake!

Handshake - the Facebook of career-services platforms for students



You've heard of LinkedIn, right? Well, what if we told you there's an even better tool you can use—a tool that you hear about every day in a series of emails that overload your mailbox, a tool that can provide you more than three times the opportunities that LinkedIn ever will. Would you be interested?

"Students find a lot more opportunities on Handshake than they would have with older systems."
- John Archambault, Assistant Dean for Student Development

Recently, the Engineering Career Services (ECS) integrated a recruitment platform called Handshake for UW–Madison students. John Archambault, Assistant Dean for Student Development, states, "Handshake is a very strong, targeted tool to help UW–Madison students find co-ops, internships, and full-time jobs." Although commonly misconceived as exclusive to engineering students, Handshake is accessible to students of all majors at UW–Madison. Since its recent introduction, there are many questions regarding choosing Handshake over the more reputable LinkedIn.

Millennials value functionality. Hence, they gravitate towards using the most popular software. This explains the near extinction of Myspace, a site that simply stopped innovating. Undergraduate students could really benefit from Handshake, which is seemingly the Facebook of career-services applications. Even though some students currently use LinkedIn, the site was created primarily for experienced professionals to network and find new opportunities. Most students assume all one needs to get an internship is to "create your [LinkedIn] profile, sit back, and get a job, but that really doesn't happen," Archambault says. "You can be found quicker in Handshake than you can if you are one of the people who has applied through the company's massive online system." On Handshake, employers are actively recruiting college students, which means students' applications are more likely to be considered for co-ops, internships, or full-time positions. These odds are better compared to applications submitted through LinkedIn, where one is part of an applicant pool of college students (from all around the world) and other professionals.

Handshake offers a multitude of resources that Archambault urges students to fully take advantage of. "You need to use all the opportunities you can to indicate your interest to that employer, whether that's through Handshake, their direct website, talking to alumni, through LinkedIn, or going to career fairs; do everything you possibly can to make connections there and get your résumé in front of prospective managers," Archambault says. At the end of the day, employers value candidates with a keen interest in their company.

Getting started with Handshake is as simple as logging in, exploring, and creating a profile. It is essential to be proactive, as this is a trait valuable to employers. Students should also add as much legitimate information as possible such as transcripts, résumés, and any additional documents that would distinguish them from other candidates. "[There are] over 100 new job postings every day, so you really need to sift through your opportunities and actively apply for positions," Archambault adds. Additionally, unlike LinkedIn, one can easily sign up for on-campus

interviews and attend information sessions on Handshake. Just like YouTube, job recommendations are personalized based on a student's use of Handshake. Students might be unaware of the benefits of Handshake if one could simply apply through LinkedIn or directly through a company's website. It is important to note that with an increase in the number of schools using Handshake, more employers will be keen on setting up a free account, thus offering students even more opportunities. The platform additionally widens the geographic range of opportunities, so "students who are interested in the East Coast or the West Coast would find a lot more opportunities than they would have with older systems such as MyECS," according to Archambault.

Mechanical engineering seniors Kelsey Hacker and Marisa Dunning enjoy using the new Handshake platform while they apply to jobs together and practice actual interview handshakes with each other.

Even with the aforementioned benefits of Handshake, Archambault reiterates, "this shouldn't be the only thing a student does; students should go beyond relying on [Handshake] but they certainly shouldn't overlook it … You want to use as many tools as you possibly can."

In addition to updating one's Handshake profile, Archambault recommends staying up-to-date on career fair information, on-campus interview dates, and job postings to make the most out their career-search experience.

There are numerous tools at students' disposal to connect with employers. However, Handshake, LinkedIn, and other recruitment tools will only get better and better at doing what they do, i.e., connecting students to employers. But it is up to the students to take the initiative and find that first internship.

So, what are you waiting for? Take the first step towards your new journey. Take your first step towards success.

Welcome to Handshake!

Written by: Nandan Venkatesan

Photography by: Beth Enright

Design by: Patricia Stan

Engineering Mental Health

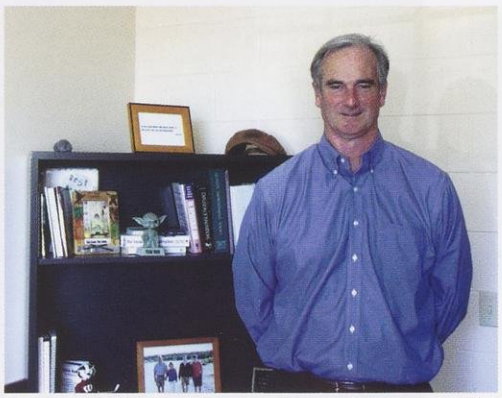
At the Great Lakes Mental Health Technology Transfer Center, Todd Molfenter and his team will apply industrial engineering principles to help organizations and K-12 schools implement effective practices to address mental health issues.

The statistics regarding mental health in the United States are alarming. According to the National Alliance on Mental Illness, 20 percent of youth live with a mental health condition with the average delay between onset symptoms and intervention being around 8 to10 years. It is natural to look to psychologists and doctors to solve this problem, but another option is the Center for Health Enhancement and System Studies (CHESS) which is centered in the department of industrial and systems engineering at UW–Madison. Todd Molfenter, assistant director of CHESS along with his team plan to address youth mental health in the Midwest while showing the diverse applications of engineering on modern societal problems.

The Center for Health Enhancement System Studies has two goals: combine technology with health care to better serve all populations and address organizational health care changes with a focus on addiction treatments. To meet their first goal, CHESS focused on using personal computer-based tools to spread accessible information in the early 2000s. But as technology advanced, CHESS moved into developing applications to perform a variety of tasks in health care. With their applications, they helped the elderly stay socially connected and assisted people in addiction recovery in preventing possible relapse. CHESS's second goal involves looking at health care from an engineering perspective to address systemic inefficiencies and identify opportunities to improve access and quality. With a history of success in helping human services organizations improve their systems and services, CHESS recently received a grant to become the Mental Health Technology Transfer Center (MHTTC) for the Great Lakes Region: serving MN, IL, IN, OH, MI, and WI.

Molfenter explains that he will try and educate counselors around "best practices around treatment and therapy."

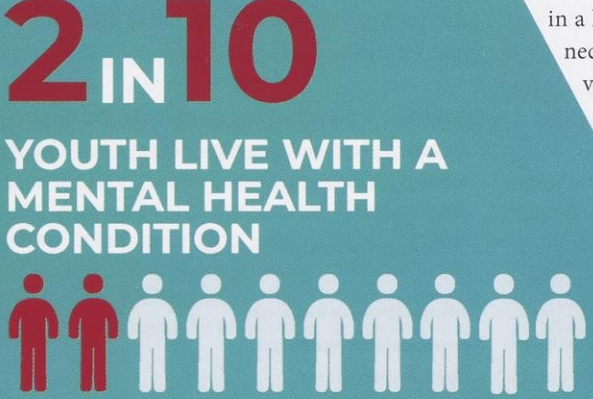
The grant was awarded by the Substance Abuse and Mental Health Services Administration which falls under the Department for Health and Human Services. As part of the grant, Molfenter will work primarily with K-12 schools to spread knowledge about mental health such as how to identify certain illnesses and how to act in response to them. In practice, this training and technical assistance will be tailored to local needs. Molfenter and his team might analyze how best to utilize a mental health provider in a high school or develop systems to connect students to consistent sources of service in extreme cases. Molfenter plans to aid school counselors as well. He explains that the MHTTC will educate counselors around "best practices around treatment and therapy." Workshops, conferences and consulting will provide this education to counselors and help the youth in the state.



Todd Molfenter hopes to address mental health issues in youth by using an array of engineering technology.

Some might wonder why exactly the grant was awarded to the College of Engineering, but Molfenter explains, "Our overall purpose is [finding] better ways of doing things." Molfenter continues that there is a long history within the department of industrial and systems engineering of working with healthcare providers using implementation sciences to study inefficient health care systems and make them operate more effectively. "We have gotten really good at that," Molfenter says.

Although the mental health crisis has taken center stage in conversations around healthcare, professors like Todd Molfenter and his team are taking pragmatic approaches to relieve it. The Mental Health Technology Transfer center will hopefully serve the Midwest by providing a large variety of services to K-12 schools and mental health professionals in the region. Molfenter's work also offers a broader picture on the application of engineering and science in the real world. The problems of today and tomorrow can't all be solved by earnest individualism; many are best resolved with an application of all areas of STEM and higher education.



Written by: Ben Hayes

Photography by: Hamoud Alshammari

Design by: Isabella Wegner

If UW-Madison Is Going to Sell Out Its Guiding Principles for Some Quick Cash, Could It At Least Do It While I'm Still a Student?

A soon-to-be-graduating student's view on the new partnership of Foxconn and UW–Madison.

You've probably heard by now that Foxconn Technology Group has announced plans to invest $100 million in engineering and innovation research here at UW–Madison, an investment which will be the largest from a research partner in the university's history and among the largest gifts UW–Madison has ever received. While I'm not exactly happy that UW–Madison, whose list of guiding principles, per the Office of the Chancellor, includes a commitment to "observe the highest ethical integrity in everything we do," is cozying up to a company with a history of famously severe labor exploitation, I'm more upset at the fact that they didn't sell out soon enough to give me a chance to directly benefit from it myself.

What the news stories regarding the announcement mostly neglected to mention was that the $100 million gift was a matching pledge. The University of WisFoxconn–Madison needs to raise its own $100 million first, or else Foxconn isn't obligated to give us a single one of those nine figures. Personally, I'm not mad about the fact that Foxconn is making us match their donation while receiving more than $4.5 billion in Wisconsin taxpayer subsidies. I'm more miffed that I won't get a chance to use all the stuff we'll buy with that sweet, sweet cash. $100 million– that's enough for like five online homework access codes!

Besides the whole subsidies thing, Foxconn's plant in Racine has also been in the news for its potential environmental impact. At one point, I did think that working with a company whose plant will become the state's largest source of pollution goes against the university's commitment to environmental stewardship. However, I then remembered that this is the University of Wisconsin–Madison, not the University of Wisconsin–Racine, so why worry? Our alumnus and famous conservationist Aldo Leopold wouldn't be happy about the damage they'll be doing to the area's wetlands, but if you gave him $100 million he'd probably change his mind.

Multiple news outlets have reported that Foxconn and UW–Madison will manage their research partnership through a joint steering committee that UW–Madison officials have said is exempt from state open meeting and open records laws. Now that just ticks me off. If the administration is going to endanger the university's academic and research autonomy and disregard UW's commitment to "fiercely defend intellectual freedom,"

"Our alumnus and famous conservationist Aldo Leopold wouldn't be happy about the damage they'll be doing to the area's wetlands, but if you gave him $100 million he'd probably change his mind."

could it do me a favor and partner with a corporation that I want to work for? Otherwise, how am I supposed to personally benefit?

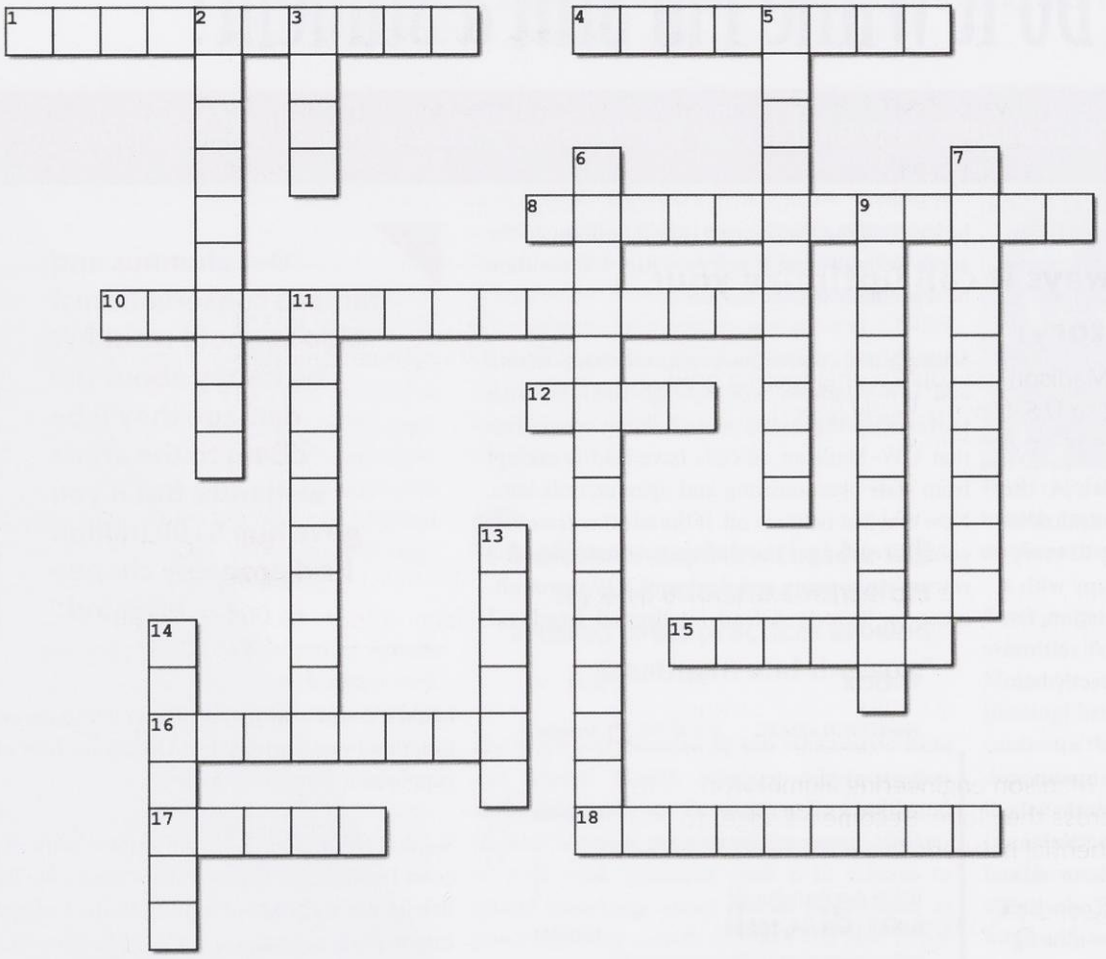
So, do I think that the establishment of the Foxconn Institute for Research in Science and Technology has a chance of leading to the College of Engineering acting as a proxy research and development department for a multi-billion-dollar corporation? Yes. Do I think that this agreement flies in the face of UW's commitment to "support learning for its own sake, throughout our lives, as a service to the greater good"? Absolutely. Am I angry about it? Not really. 1410 Engineering Drive could use a facelift anyway. I'm just annoyed I won't have a chance to study in the brand-new building they'll replace it with. I bet the computer labs in there will have dual monitors too!

Written by: Patrick Byrne

Image by: Patrick Byrne

Design by: Suzanne Kukec

THE ENGINEERS' CROSSWORD



Across

1. The failure of light rays to converge at one focus due to limitations or defects in a thin lens or mirror
4. Alpha-glucosidase inhibitors such as Miglitol can help regulate symptoms of this disease
8. Type of magnetic chemical interaction occurring between two polar molecules
10. The most efficient, but very expensive, type of solar cell
12. Compiler flag which turns on all compile-time errors and warnings
15. A general-purpose programming language known for its readability, simplicity and application towards scientific endeavors
16. A cheaper, more flexible type of solar cell made by depositing thin layers of photovoltaic film
17. Circuit component capable of producing a voltage hundreds of thousands of times larger than the input voltage differential
18. Something operated by liquid moving in a confined space, under pressure

Down

2. A method for approximating an integral using a finite sum, often defined by a series of rectangles
3. A unit of pressure defined on an absolute scale
5. Broad term for histone tail modifications or DNA methylation affecting gene expression
6. The First Lady of Engineering!
7. The rumbling or gurgling noises caused by the movement of liquid and gas through the bowels
9. Type of software testing where the interactions and assumptions between individual units are tested
11. How heat transfers through a solid object
13. The oft-forgotten fourth fundamental state of matter, characterized by high electrical conductivity
14. Type of derivative security investment that can be Call or Put and has a strike price and expiration date

Design by: James Earley, Eric Shumaker, and James Johnston

Solutions can be found at: wisconsinengineer.com/crossword

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Program at a glance

Timeframe: Three semesters (fall, spring, summer), for a total of 12 months.

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Requirements: Coursework only, no thesis. At least 30 credits required for master of science degree.

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Questions?

Contact Program Director Lee DeBaillie, at 608-262-2329 or debaillie@wisc.edu.

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